

The Delphi technique in Radiography Education research

Introduction

The purpose of this review article is to explore the role of the Delphi method as a tool for radiographers seeking to employ a mixed method research approach to obtain collective agreement on a topic across a broad section of the radiography profession. This will be achieved by describing the Delphi technique and critically evaluating this data collection tool as previously used in radiography education. The latter part of the article will demonstrate a worked example of a research protocol to design an MRI education intervention, and associated learning outcomes, for undergraduate diagnostic radiography learners.

The Delphi Technique

The Delphi technique was devised at the beginning of the Cold War (late 1940s), to study inter-continental warfare and to anticipate the impact of technology on combat¹. At the time, shortcomings of traditional forecasting methods including theoretical approaches, quantitative models, and trend exploration were recognised¹. Collective agreement in the Delphi technique refers to collective agreement and usually involves collaboration rather than compromise. Stakeholders are brought together and through the guidance of a facilitator work until there is a convergence of opinion². The 'classical Delphi technique' comprises of the following stages:

Stage 1: A problem is posed to a panel of experts

Stage 2: Individually the panel of experts responds with a list of criteria to address the problem

Stage 3: The combined list is circulated to the individual panel members for ranking

Stage 4: Data gathered is analysed and reworked towards collective agreement

Stage 5: Stage 3 and 4 are repeated for several rounds

Stage 6: Collective agreement is achieved through a method of identifying settlement from ranking (i.e. statistical testing).

However the Delphi technique has evolved over time with different types being available to the researcher ² - table 1.

Table 1. Types of Delphi techniques and main characteristics ²

DELPHI TYPE	Main Characteristics
Classical	Uses an initial round whereby opinions and judgements on a particular issue are sought from “informed individuals”. From here the data is summarised and a revised questionnaire is designed based solely on results obtained from the first round. This type usually involves three or more postal rounds.
Modified	The first postal round is replaced with face-to-face interviews; focus groups or through developing statements from the literature. Subsequent rounds follow same structure as classical Delphi.
Decision	Focuses on decision making rather than achieving consensus
Policy	Uses expert opinion to agree future policy
Real-time	Collective agreement reached in real time rather than by post. Sometimes referred to as a consensus conference
e-Delphi	Administered by email or online survey
Technological	Uses technology such as a hand-held device keypad allowing experts to respond to questions immediately thus allowing immediate mean/median scores.
Argument	Produces relevant factual arguments. Derivative of the policy Delphi

There is no agreement in literature on the ontological position and epistemological status of the Delphi technique. Arguments also exist regarding which paradigm the Delphi method belongs - qualitative or quantitative. The primary reason for this is because with some Delphi type's data can be collected using qualitative and quantitative methods. A seminal paper on these observations ³ argues that scientific fields have yet to be developed which allow the testimony of experts to be permissible. Sixty years later and this viewpoint still remains.

The Delphi Method in Healthcare Education Research

As evidenced by a Science Direct database search, the use of Delphi in healthcare research is growing in popularity. Using the search terms “*Delphi technique*” and “*Delphi method*”, nursing and health care professional journals were examined within the title, abstract and key-words of English language papers appearing between 2011 and 2016. This yielded 410 articles. An observation of increasing acceptance is strengthened by a similar search performed for the previous six year period (2005 and 2010) ², whereby 237 articles were identified-table 2. Suggested reasons for this increased popularity the increase in the volume of scholarly articles published and through advancements in information technology, large numbers of individuals across a diverse geographic location can engage with this type of data collection. Hence findings from using the technique can inform priorities and guidelines at a national or international level ⁴.

Table 2. Frequency of Delphi Papers in Science Direct each year since 2005

Year	No. of Articles	Year	No. of articles
2005	27	2011	50
2006	33	2012	57
2007	40	2013	48
2008	38	2014	86
2009	47	2015	66
2010	52	2016	103
Total	237	Total	410

In the papers uncovered in these searches, the Delphi technique was utilised to identify health care themes including core competencies; research priorities; professional workload and clinical guidelines. Narrowing the search to the role of the Delphi technique within healthcare education highlights 90 articles that use the technique with defining competencies being the most common use for the tool⁵. In addition to this the technique has also been applied to the collection of data for curriculum development, curriculum renewal and assessment.

Based on these observations, the research team sought to isolate radiography

education literature using this method between 1993 (the first year the radiography curriculum moved from local radiography school diplomas to degrees within higher education institutes in the UK ⁶) and the present day. The search terms used were expanded by incorporating the word *radiography*. This showed that the use of the Delphi technique within radiography education was less common, with only four peer-reviewed published studies identified ^{7, 8, 9, 10}. This contrasts the number of articles across all healthcare professions as highlighted in table 2. Of those identified, two papers explored UK learner competency ^{7, 10}; with both forecasting future learning requirements ^{7, 10} and one reviewing the Delphi technique ⁸. The fourth paper ⁹ addressed supervision skills. Using Google Scholar to identify unpublished research in the field, a further master's dissertation was identified¹¹. This explored South African undergraduate diagnostic radiography learner competency.

Delphi versus other group collective agreement procedures.

The purpose of the data collection for the worked example in this review paper is to achieve agreement among a group of experts on a central issue where none previously exists ¹². Within radiography education literature there are examples of group-based data collection techniques to establish group consensus. These include Focus Groups¹³, the Nominal Group Technique (NGT) ¹⁴ and Interacting Groups ¹⁵. Whereas there is a plethora of articles which utilise focus groups, the NGT is not used as often ¹⁶. A third recognised method, interacting groups¹⁵, is absent from the radiography literature.

A focus group allows a group of experts to come together and discuss an issue. Advantages of this tool are full and complete responses, clarification through follow-up questions and captive subjects ¹⁷. Even so this can be a disadvantage as individuals in a group scenario may conform to group responses and there may be issues with some members of the group being reticent ⁸. On the other hand NGT, through a trained facilitator uses a highly structured format to gather information from all group members whilst still permitting individuals to rank the importance of the group's topics of discussion ¹⁶. Through this, issues with group dynamics are decreased ¹⁴ although they are not eliminated. Hence for both methods there

remains concern with participant anonymity and how this impacts on the final decision. Although total anonymity cannot be guaranteed with the Delphi technique as the respondents may know each other, their judgements and opinions are kept anonymous and only the researcher has access to this information ². Not knowing individual contributions allows for opinion modification between rounds. This is particularly helpful when there is a range of grades of staff within the sample as power-dynamics is less of an issue ¹⁴.

However, drawing from a single professional group is not without its challenges. Pooling from a group of radiography experts can mean there is the possibility they will know each other, especially given the limited number of radiographers working in sub-specialist areas. This is not an issue to the technique however there is no way in ascertaining if those partaking in a Delphi study have not discussed their thoughts with colleagues or fellow panel members prior to completing the paperwork thus skewing the answers given ¹⁸. Hence it is important to ensure participant responses are kept anonymous. This can be a challenge with the Delphi technique as the researcher needs to link each expert with their response. Assigning a unique code to every participant that is stored on a password protected PC only accessible to the researcher(s) working on the study can help overcome this.

Worked Example: Identifying Undergraduate MRI Proficiency Standards

The following worked example is an outline of a study that is to be repeated based on previous unpublished work by the first author of this paper.

Rationale for the suggested study

Currently Health and Care Professions Council (HCPC) registered diagnostic radiographers are listed on the UK shortage occupations register with Scotland including magnetic resonance imaging (MRI) radiographers ¹⁹. This shortage runs in parallel with increasing numbers of MRI scans being performed with a rise of 8% documented in 2016 for England alone ²⁰.

While the National Health Service (NHS) remains the main employer for newly qualified healthcare professionals in the UK and a standard first-post includes general imaging ²¹, in recent years there has been a growth in opportunities for this group to specialise in MRI through “Graduate Training Schemes” ^{22, 23}. Graduate programmes have been long established for graduates in science, management and engineering ²⁴. Akin to these schemes, radiography programmes can last from six to eighteen months, combining clinical learning and local training competencies ^{22,, 23}. In parallel to this alternative career route, there is a general collective agreement within radiography that a rethink is required for pre-registration radiography education in England ^{25, 26}. This has become necessary following the 2016 government comprehensive spending review ²⁷ whereby allied health students in England will be required to pay fees of up to £9,250 per year from 2017/ 2018.

Despite some radiography learners wishing to pursue a career in MRI and an identified shortage of trained individuals, the HCPC standards of proficiency in this area for a newly qualified radiographer is minimal when compared to fields such as Computed Tomography (CT) and general imaging ²⁸. At the lead researcher’s institution, we identified a lack of MRI learning opportunities, compared to other specialist areas of practice through a document analysis exercise (unpublished data).

The document analysis exercise was conducted as follows: a College of Radiographers (CoR) ²⁹ curriculum validation mapping document was used to identify, modules, clinical documents and schemes of work which included MRI training. These were then cross-referenced against the lead researchers undergraduate diagnostic imaging programme handbook to ensure no information was missing. From here the most recent version of each document pertaining to MRI was downloaded from the virtual learning environment, a tool accessed by both learners and the programme team ³⁰.

The finding of limited MRI learning opportunities is supported by qualitative feedback from undergraduate learners through module and clinical placement evaluation forms completed by learners studying at the higher education institute in question. Here learners reported a lack of engagement during MRI clinical weeks.

Observations made by learners are that they are at times uncomfortable, unsupervised and occasionally unwelcomed- themes identified in previous research³¹. This feedback contrasts clinical experiences in other areas of practice whereby learners felt useful and part of the team. Hence changing graduate radiography workforce requirements, coupled with enhancing learner experience, informed the decision to develop and design an MRI specific education package for undergraduate learners using the Delphi technique

Expert Panel

The purpose of the Delphi technique is to capture opinion in a formal structured way. It is argued that those invited to input into a Delphi process need expertise and knowledge of the topic under investigation. For pre-registration radiography training this requires balancing regulatory body requirements with eliciting the input from those who are working in service and involved in workforce development in curriculum development. One challenge in healthcare curriculum design is defining who these experts are especially as there is an array of stakeholders in this activity including educators, service managers, those working clinically in service, learners, the public and patients.^{32, 33, 35}. A viewpoint on learner involvement is that they may not afford useful contributions on the basis that it is difficult to determine required knowledge without having completed the required training or passed the speciality examinations³⁵. However the researchers observe that the validation of programmes of study with professional registration requires learner involvement^{29, 36}. Another overlooked stakeholder group in the literature is newly qualified practitioners. The research team believe it is essential to engage this workforce as they will have first-hand experience of post-registration training requirements.

Sampling & Size of the Expert Panel

One shortcoming of the Delphi technique is that there is little guidance on the size of the “expert panel” needed and it is difficult to determine “experts” on a particular issue³⁷. However as long as the members are representative of their organisation

their inclusion is justified ⁶. Some studies have looked at self-rating expertise as a valid method of identifying panel members ^{37, 38}. Others have found the opposite ^{39, 40}, a point the researchers acknowledge given the challenges of applying the term to patient and public panel members. Likewise, there is no consensus on the size of the panel for this data collection method with studies citing numbers ranging from one to three thousand ². In previously reported radiography education research, using the Delphi technique one study used 51 experts ⁷, another used 15 ⁸ with a commonality of purposive heterogeneous sampling noted.

As per previous radiography education research ⁷, the clinical governance lead at the private imaging company will advise on experts drawing from all the relevant stakeholders. The size of the panel will be determined by the number of proposed names. It is envisaged the panel will include training managers, radiographers with training responsibilities, new recruits on the graduate training programme, patients and third year learners who undertake a clinical placement opportunity with this private imaging provider.

Collective Agreement and Feedback

There are various levels of statistical testing used to quantify collective agreement when using the classical Delphi technique. This includes standard deviation, chi-square and medians ⁴¹. For earlier radiography education research papers collective agreement was said to have been reached when 75% ¹¹ or 80% ⁷ of the votes satisfied a particular numeric value on a range. This contrasts with later research whereby interquartile ranges have been adopted with collected agreement noted where an interquartile range was set as greater than or equal to one ¹⁰. For modified Delphi approaches more qualitative methods of “reasons” feedback have been documented ². Unfortunately published Delphi studies rarely provide a definition of what constitutes consensus, employ arbitrary levels or state the level post hoc in the data analysis section.

In general, it is unclear how the Delphi technique actually contributes to a shift towards consensus; is it on the basis of new information or social pressure? It has been demonstrated that when panellists are given distorted feedback between

iterations they confirm their rating through false information ⁴². Other challenges relate to managing outliers or minority opinion. On one hand it is acknowledged that the overall aim of an expert panel is to find broad areas of agreement and therefore outliers should be disregarded ⁴³. On the other it is argued that it is worth monitoring these responses ⁴⁴, asking participants to give reasons to their qualitative choices ⁴⁵. Based on this the rounds for this project will be administrated as follows.

Data Collection

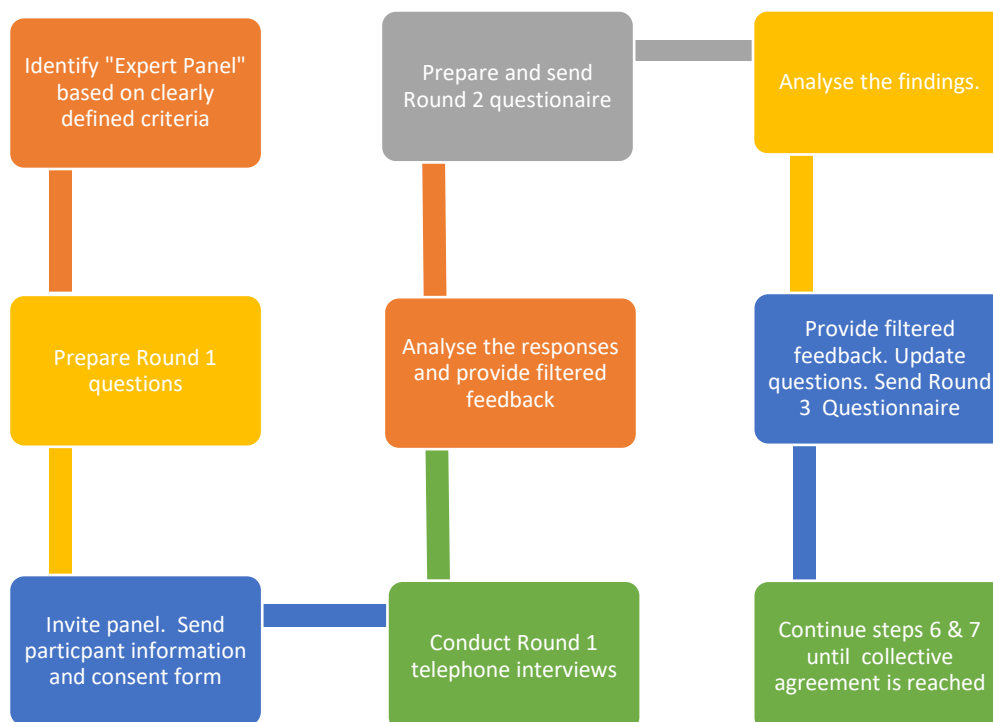
For this protocol, on-line completion allows nation-wide coverage, a condition which is difficult to achieve with NGT and focus groups without significant funds ². The first round will be conducted via telephone interview using open-ended questions thus collecting qualitative data. Interactions with the Delphi participants from the beginning will be adopted to assist with decreasing attrition rates of participant between the rounds. As noted earlier this will be managed carefully to maintain autonomy of answers between those on the expert panel ¹². Attrition can happen during any of the rounds with distractions between rounds and fatigue with the process listed as main reasons for this ⁴⁴. However in radiography research an increase in participation between rounds one and two is noted in one paper ¹¹ by ensuring those who opted out of round one were still approached for round two. It is unclear how this impacted the final findings. Participants will be encouraged to give reasoned feedback on their choices of MRI proficiencies. The answers provided will be sifted by the research team with filtered reason feedback supplied alongside the round two questionnaire as statements.

Using a questionnaire as a tool for round two onwards enforces the merits of scientific inquiry. Statements produced will be ranked using a Likert scale, and rounds continued until collective agreement is reached on some or all of the items ¹³. A five point Likert scale will be used to measure either positive or negative responses to each competency listed with 5 points for strong agreement reducing to 1 point for strong disagreement ¹⁰. Collective agreement will be reached when 75% of the votes fall within a range. To ensure minimal attrition, a quick turn-around of data collection will be in place to enhance participant enthusiasm. For this reason a response time of two weeks will be actioned for each round. Rounds will continue

until collective agreement is reached. Fewer questions will be asked through the iterations allowing convergence of opinion amongst stakeholders. This will not mean that the correct answer has been found but rather that the experts have come to an agreement on the issue (s) being explored ²- figure 1.

One area of concern in supplying a mixed feedback approach assumes the research team providing the feedback is objective. This will not be the case for this project as the lead researcher teaches undergraduate and postgraduate learners' cross-sectional imaging. Subsequently when providing filtered reasons feedback it is important for the researcher to demonstrate reflexivity and reflect on how their views may influence the feedback for the first round ². Nevertheless being knowledgeable of the area under investigation is not entirely negative as it can add depth to the reasoning ⁴⁵.

Figure 1. Data Collection for Worked Example



Stakeholder Satisfaction with Output

On completion of the Delphi study, stakeholder satisfaction with the output will be

assessed using a broader sample. This could be achieved by sending the results to the British Association of MR Radiographers policy board to distribute for consultation ⁴⁵. The Association promotes the professional development of Radiographers and other associated professionals within the speciality of MRI, through encouraging and developing educational forums. Although the evidence yielded from this will be low on Kirkpatrick's model for evaluating effectiveness of training ⁴⁶, it is useful as stakeholder engagement is essential for translating these research findings into educational practice ⁵⁸.

Conclusion

Originally seen as a forecasting tool, the Delphi technique also has a function in curriculum design. Development of the educational requirements for radiographer's pre- and post-registration in the field of cross-sectional imaging, in this worked example MRI, continues to evolve and there is a need for higher education providers to respond to these. Application of this mixed-methods research method for this purpose is demonstrated by the worked example within this article. Comparable to all group collective agreement methods the Delphi technique has advantages and disadvantages. However the ability to easily sample a wide audience over a large geographical area coupled with participant autonomy makes this a suitable group collective agreement technique. Furthermore by involving a wide range of stakeholders through participatory consultation, acceptance of change to current education programmes is more likely.

References

1. Helmer, O. Analysis of the Future: The Delphi Method. 1967. Available at: <http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=AD0649640> [Accessed 30 December 2016]
2. Keeney, S., Hasson, F. & McKenna, H. *The Delphi Technique. Nursing and Health Research*. Oxford: Wiley-Blackwell; 2010
3. Helmer, O. & Rescher, N. On epistemology of inexact sciences. *Management Science*, 1959; 6 (10), 25-52
4. Berretta, R. A Critical Review of the Delphi Technique. *Nurse Researcher*, 1996; 3(4), 79-89.
5. Fotha, T., Efstathiub, N., Vanderspank-Wrightc, B., Ufholzd, L.A., Dütthorne, N., Zimanskyf, M & Humphrey-Murto, S. The use of Delphi and Nominal Group Technique in nursing education: A review. *International Journal of Nursing Studies*, 2016; 60, 112-120
6. Pratt, S. & Adams, C. How to create a degree course in radiography: a recipe. *Radiography*, 2003; 91, 317-322.
7. Williams, P.L. & Berry, J. What is competence? A new model for diagnostic radiographers: Part 1. *Radiography*, 1999; 5, 221-235.
8. Williams, P. L. & Webb, C. (1994a). The Delphi technique: a methodological discussion. *Journal of Advanced Nursing*, 1994; 16, 180-186.
9. Williams, P.L. & Webb, C. Clinical supervision skills: a Delphi and critical incident technique study. *Medical Teacher*, 1994; 16, 139-157.
10. Castillo, J., Caruana, C.J., Morgan, P.S., & Westbrook, C. Radiographer managers and service development: A Delphi study to determine an MRI service portfolio for year 2020. *Radiography*, 2005; 21, e21-e27
11. Davidson, F. W. Using the Delphi technique to define the clinical competencies required by newly qualified diagnostic radiographers in South Africa. Retrieved April 30 from: <http://digitalknowledge.cput.ac.za/jspui/handle/11189/788> [Accessed: 20 December 2016]
12. Beretta, R. A critical review of the Delphi Technique, *Nurse Researcher*, 1996; 3(4), 79-89

13. Merton, R. K. & Kendall, L. P. The focused interview. *American Journal of Sociology*, 1946; 51(6), 541-557
14. Delbecq, A. L. & VandeVen, A. H. A Group Process Model for Problem Identification and Program Planning. *Journal Of Applied Behavioural Science*, 1971; 7: 466–91
15. Clayton, M.J. Delphi: a technique to harness expert opinion for critical decision-making tasks in education. *Educational Psychology*, 1997; 17(4)
16. Williams, P., White, N., Klem, R. & Wilson, S.E. Clinical education and training: Using the nominal group technique in research with radiographers to identify factors affecting quality and capacity. *Radiography*, 2006; 12(3), 215-224
17. Ramlaul, A, *Medical Imaging and Radiotherapy Research* (pp.11-17). China: Elsevier; 2010
18. Keeney, S. The Delphi Technique. In: Gerrish, K. & Lacey, A. (Eds.), *The research process in Nursing*. London: Backwell Publishing, 2009
19. Home Office. *Shortage Occupation List*. Available at: <https://www.gov.uk/government/publications/tier-2-shortage-occupation-list> [Accessed 30 December 2016]
20. NHS England. *Diagnostic Imaging Dataset*. Available at: <https://www.england.nhs.uk/statistics/statistical-work-areas/diagnostic-imaging-dataset/> [Accessed: 28 December 2016]
21. Society of Radiographers. *Diagnostic Radiography UK Workforce Report 2016*. Available at: <https://www.sor.org/learning/document-library/diagnostic-radiography-uk-workforce-report-2016> [Accessed 31 December 2016]
22. InHealth. *Training and Job Vacancies*. Available at: <https://www.inhealthgroup.com/about/training-and-development> [Accessed 30 December 2016]
23. Alliance Medical Ltd. *Career Opportunities*. Available at: <http://inside.alliancemedical.co.uk/apply/Careers.aspx> [Accessed 30 December 2016]
24. Graduate Jobs. *Graduate Jobs, Schemes, Internships & Advice*. Available at: <https://www.graduate-jobs.com/> [Accessed 30 December 2016]
25. Nightingale, J. Radiography education funding- opportunity or crisis. *Radiography*, 2016; 22 (2), 105-106

26. Sloane, C. Challenges and opportunities in educating the medical imaging Practitioner. *Imaging & Oncology*. Available at: https://www.sor.org/system/files/article/201606/io_2016_lr.pdf [Accessed 29 December 2015].
27. Department of Health. Policy paper – NHS bursary reform. Available at: <https://www.gov.uk/government/publications/nhs-bursary-reform> [Accessed: 20 December 2016].
28. Health and Care Professions Council (HCPC). Standards of Proficiency- Radiographers. Available at: <http://hpc-uk.org/publications/standards/index.asp?id=51> [Accessed 20 December 2016]
29. College of Radiographers. *Education Approval and Accreditation*. Available at: <http://www.sor.org/learning/education-accreditation/education-approval-and-accreditation?autologout=1> [Accessed 15 December 2016]
30. Fry, H., Ketteridge, S. & Marshall, S. “*A Handbook for Teaching and Learning in Higher Education: Enhancing Academic Practice*” 4th. Ed. Routledge: London, 2009.
31. Mifsud, C. P.; Castillo, J., Portelli, J. L. Radiography students' clinical placement experiences in MRI: A phenomenological study. *Radiography*, 2015; 21(1), e17-e20
32. Starkweather, D.B., Gelwicks, L. & Newcomer, R. Delphi forecasting of health care organisation. *Inquiry*, (1975); 2(1), 37-46
33. Synowiez, B. & Synowiez, P. Delphi forecasting as a planning tool. *Nursing Management*, 1990; 21(4), 18-19
34. Moore, C. M. Delphi technique and the mail questionnaire, In: *Group Techniques for Idea Building: Applied Social Research Methods*. Sage Publications, California: 1987
35. Kilroy, D. & Driscoll, P. Determination of required anatomical knowledge for clinical practice in emergency medicine: national curriculum planning using a modified Delphi technique. *Journal of Emergency Medicine*, 2006; 23, 693-696
36. Health and Care Professions Council (HCPC). *Approval and Monitoring Processes*. Available at: <http://www.hcpc-uk.org/education/processes/approval/> [Accessed: 15 December 2016]

37. Dalkey, N., Brown, B. & Cochran, S. The Delphi method III: use of self-ratings to improve group estimates. *Technological Forecasting*, 1970; 1, 283-291.
38. Best, R. An experiment in Delphi estimation in marketing decision making. *Journal of Marketing Research*, 1974; 1, 448-45
39. Brockhoff, K. The performance of forecasting groups in computer dialogue and face to face discussions. In: Linstone, H. & Turroff, M. (Eds), *The Delphi method: techniques and applications*, Addison-Wesley: London; 1975
40. Larreche, J. & Moinpour, R. Managerial judgement in marketing: the concept of expertise, *Journal of Marketing Research*, 1985; 8, 443-448.
41. Parente, F. & Anderson-Parente, J. Delphi inquiry systems. In: Wright, G. & Ayton, P. (Eds.), *Judgmental forecasting*. Wiley: Chichester; 1987
42. Rowe, G., & Wright, G. The impact of task characteristics on the performance of structured group forecasting techniques. *International Journal of Forecasting*, 1999; 15, 353-375
43. Cyphert, F. & Grant, W. The Delphi Technique. *Journal of Teacher Education*. 1970; 21, 422-431
44. Scott, E, & Balck, N. When does consensus exist in expert panels? *Journal of Public Health Medicine*, 1991; 13 (1), 36-39
45. Donohoe, H.M. & Needham, R.D. Moving best practice forward: Delphi characteristics, advantages and potential problems and solutions. *International Journal of Tourism Research*, 2008; 11, 415-437
46. British Association of MR Radiographers. *Meet the Policy Board*. Available at: <http://www.bamrr.org/about-us/policy-board>. [Accessed: 29 December 2016]
47. Kirkpatrick Partners. *The Kirkpatrick model*. Available at: <http://www.kirkpatrickpartners.com/OurPhilosophy/TheKirkpatrickModel> [Accessed: 01 December 2016]

